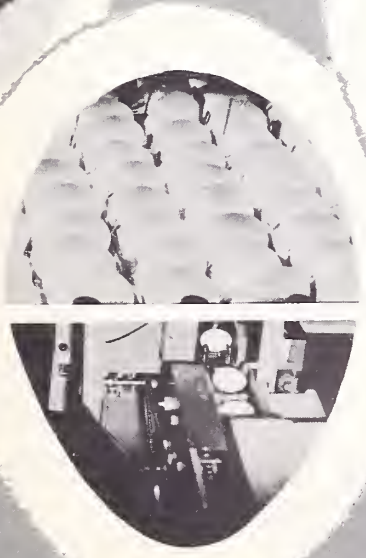
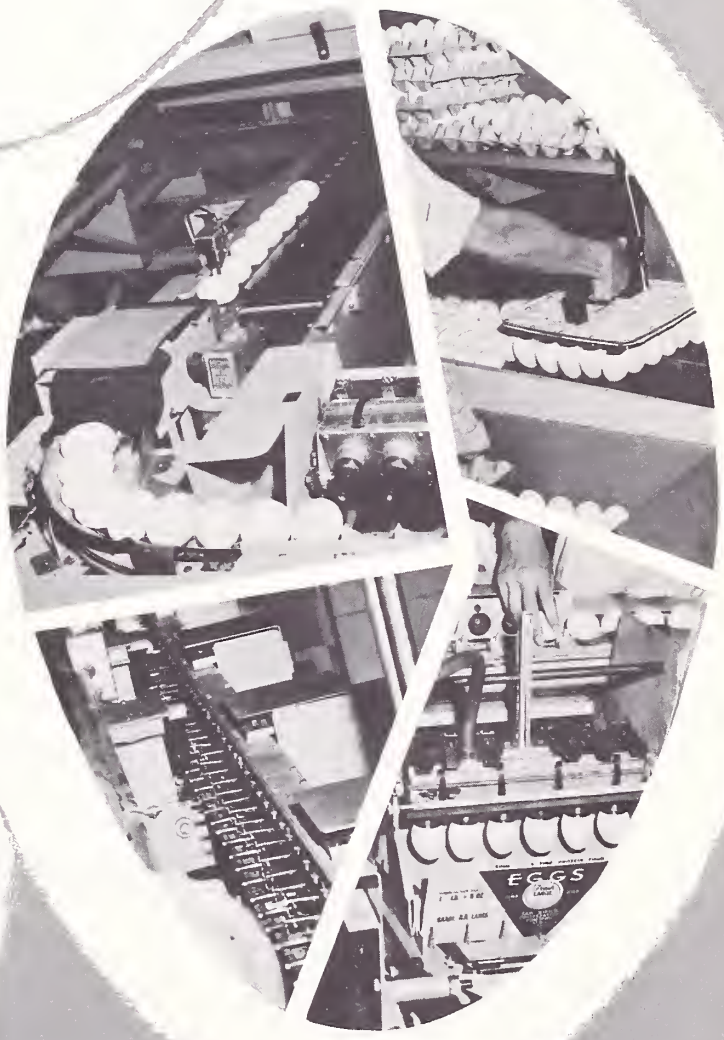
AUTOMATIC SIZING and PACKAGING of EGGS





MARKETING RESEARCH REPORT NO. 424
Agricultural Marketing Service
Transportation and Facilities Research Division
UNITED STATES DEPARTMENT OF AGRICULTURE

Preface

This report is a continuation of research in mechanization of egg grading and packing reported in Marketing Research Report No. 239, "Electronic Bloodspot Detection in Commercial Egg Grading." That report showed that effective flash candling (group scanning) and electronic bloodspot detection could eliminate the need for hand candling eggs of uniformly fine quality to assure that they comply with consumer grade requirements. It was evident from those studies that even greater cost reductions could be accomplished through automatic sizing and packaging. In this report, further mechanization of the egg grading operation, by modifying the original experimental line, is explained and evaluated. It is a detailed presentation of the research recently reported in the sound film, "Mechanization of Egg Grading and Packing". The study is part of a nationwide research program to reduce costs and improve efficiency in marketing farm products.

The study was conducted in a commercial egg grading and packing plant in San Diego, Calif., under the direct supervision of John A. Hamann, research analyst, Handling and Facilities Research Branch, Transportation and Facilities Research Division.

The author acknowledges the assistance and cooperation of:

The San Diego Co-operative Poultry Association, which provided eggs and furnished facilities and grading and packing labor for trial runs and test purposes.

Food Systems, Inc., Berkeley, Calif., which furnished the electronic bloodspot detector and the service on it during the tests.

Harry E. Drews, Springfield, Mo., who constructed the experimental grading and packing line.

Barker Egg Equipment Company, Ottumwa, Iowa, which fabricated many of the components of the line.

Continental Can Company, Inc., whose Robert Gair Paper Products Group fabricated the mechanical egg carton dispensers.

Karl Norris, Market Quality Research Division, AMS, who supervised egg breakout tests.

Contents

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Summary

Two additional steps toward mechanizing the egg grading and packing operation were made by the U.S. Department of Agriculture when in-line sizing and automatic packaging were added to an experimental line developed in an earlier study. The new line, operating under test conditions similar to those of the first study, was evaluated as to labor requirements and ownership costs required by the additional steps toward complete mechanization (see Marketing Research Report No. 239, "Electronic Bloodspot Detection in Commercial Egg Grading"). The data showed that the addition of in-line sizing and mechanized packaging resulted in lower costs than were experienced in either the partly mechanized operation with out-of-line sizing, or hand candling with out-of-line sizing. They compare as follows:

Type of operation	*Cost per case (Cents)*
Hand candling and manual packaging, eggs sized separately	5
Flash candling, electronic bloodspot detection, and manual packaging, eggs sized separately	5
Group scanning, electronic bloodspot detection, and in-line automatic sizing and packaging	4

Even though limitations on successful operation confine the use of this automatic equipment to eggs of uniformly fine quality in plants having good maintenance facilities, the savings, projected to include only one-fourth of the national production, would amount to $1.6 million annually.

AUTOMATIC SIZING AND PACKAGING OF EGGS

By Evans R. Winter, industrial engineer, Transportation and Facilities Research Division

Background

In a recent study of a commercial egg grading operation employing group scanning and electronic bloodspot detection,[1] it was determined that it is unnecessary to hand candle eggs of uniformly high quality. But the benefits of these improvements could not be maximized unless rapid in-line sizing and packaging equipment also could be developed and included in the line. Time studies had shown that, after elimination of manual candling, nearly a third of the original labor requirement was still necessary for picking up eggs and placing them into containers. Automatic packaging equipment could reduce the remaining labor requirements by 50 percent. Further labor savings and less breakage would be made possible by segregating the eggs into size classes in the same operation. The significance of these savings is reflected in the fact that grading and packing costs were more than one-third [2] of the costs of marketing the estimated 4.8 billion dozen eggs sold off U.S. farms in 1959.[3]

Accordingly, Department engineers and marketing specialists improved and modified the original experimental line to include devices for automatic in-line sizing and packaging (in this report, "packaging" refers to placing eggs in one-dozen cartons, and "packing" is placing filled cartons in master containers). The new line represents encouraging progress in mechanization of the entire grading and packing operation in both large and small plants handling eggs of uniformly fine quality from controlled flocks.

Objectives and Procedures

The objectives of this study were: (1) Development of high-speed in-line egg sizing and new packaging methods and equipment as integral parts of a mechanized grading line developed by the Department of Agriculture in an earlier study; (2) modification of the original experimental line to include the new equipment; (3) evaluation of the performance of the modified line in terms of grading, sizing, and packaging accuracy, and product condition; (4) determination of labor requirements for operation of the line under commercial conditions; and (5) comparison of the labor and equipment costs of the modified line with the costs of the less highly mechanized operations studied during tests of the original line.

The steps taken in the development, testing, and evaluation of the new line were:

(1) The original experimental line was modified to include mechanized in-line scales and packaging equipment, in addition to improved group viewing (flash candling) and electronic bloodspot detecting equipment (fig. 1).

(2) Workers were trained in the operation of the new equipment.

(3) The bloodspot detector, scales, and packaging equipment were checked for grading and positioning accuracy, during operation under commercial conditions.

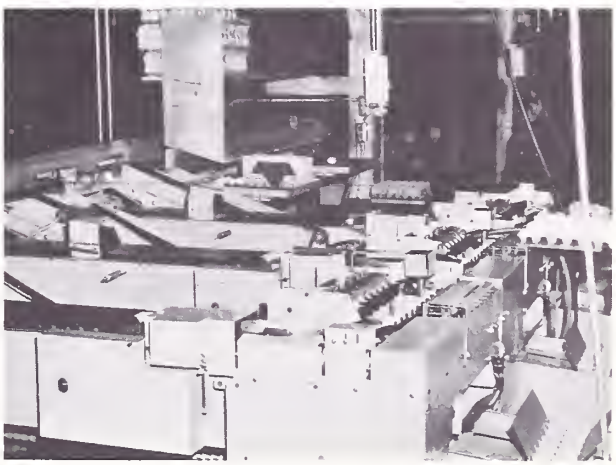

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Figure 1.—Automatic egg packaging units for three size classes.

[1] Hamann, John A., Winter, Evans R., Stoyanoff, Robert, and Hester, O. C., "Electronic Bloodspot Detection in Commercial Egg Grading." U.S. Dept. Agr., Mktg. Res. Rpt. No. 239, 65 pp. Illus. 1958.

[2] Estimate based on data taken from "Candling and Cartoning Eggs at Country Plants," by Robert M. Conlogue, U.S. Dept. Agr., Mktg. Res. Rpt. No. 366, 16 pp. 1959.

[3] Agricultural Marketing Service, "Farm Production, Disposition, Cash Receipts, and Gross Income, 1958–59," Pou. 2–3 (60), p. 12. 1960.

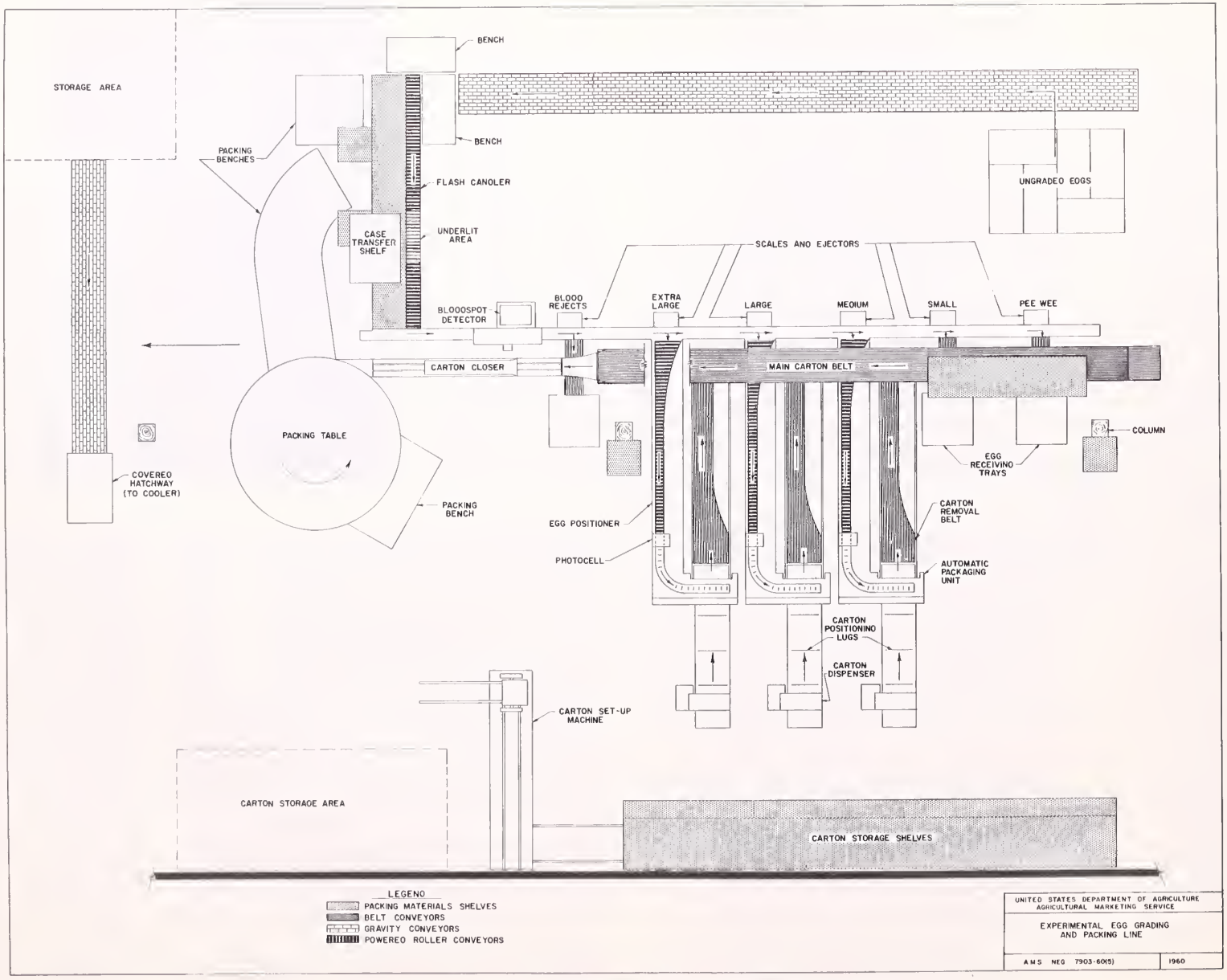

Figure 2.—Layout of experimental grading and packing line.

(4) Production samples were drawn periodically, to verify accuracy and product condition during all operations.

(5) Labor requirements and production rates were determined from time study data and production records.

(6) Breakout tests were made for direct comparison of the effectiveness of the visual and electronic methods of bloodspot detecting.

(7) Labor and equipment costs were developed and compared with the costs of the methods and equipment used in the earlier study.

Description of Equipment

The new line (fig. 2) consists of 10 major components: (1) A powered flash candler-conveyor with rubber-covered rollers for receiving eggs, and special illumination for viewing exterior and interior egg quality; (2) a single-filing device, called a "singulator," to translate eggs from 6 abreast to single file; (3) an improved commercial model of the bloodspot detector; (4) in-line scales for segregating eggs into 5 size classes; (5) egg positioners and automatic packaging units for 3 of the 5 size classes; (6) carton dispensers and positioners for each of the automatic packaging units; (7) cartoned-egg conveyor belts; (8) receiving trays and shelves for manual packaging of eggs of infrequently occurring sizes and qualities; (9) a carton closer; and (10) a carton packing table.

The overall dimensions of the line are approximately 22 by 33 feet. The grading, sizing, and packaging equipment occupies an area measuring 19 by 21 feet.[4]

The only components of the original experimental grading line remaining unchanged are the single-filing device, the rubberized roller conveyor for receiving ungraded eggs, the main carton belt, and the cartoned-egg packing table. All other components were modified or newly developed.

Flash-Candler Conveyor and Singulator

The flash-candler conveyor (fig. 3), a modified version of the unit used in the earlier partly mechanized line, provides better illumination and improved light shields. It enables better determination of egg quality with less operator fatigue than was the case in the original line.

The receiving end of the conveyor, where eggs are transferred from 30-dozen cases to rubber-covered rollers in six-abreast formation, is illuminated by a small overhead lamp for examination for exterior defects. The eggs are turned slowly as they advance toward the flash-candling area, where they are rotated rapidly as they pass over a set of mercury vapor lamps (fig. 4). A reflector and baffle assembly concentrates the light on the eggs and directs stray light away from the operator's eyes. In this area, eggs with interior defects are detected and removed.

[4] Commercial models measuring 12 by 21 feet are now available.

After leaving the flash-candling area, the eggs are delivered to the "singulator" (fig. 5), where they are changed from six-abreast formation into a single file for delivery to the bloodspot detector.

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Figure 3.—Operator loading eggs into the grading and packing line at the in-feed conveyor.

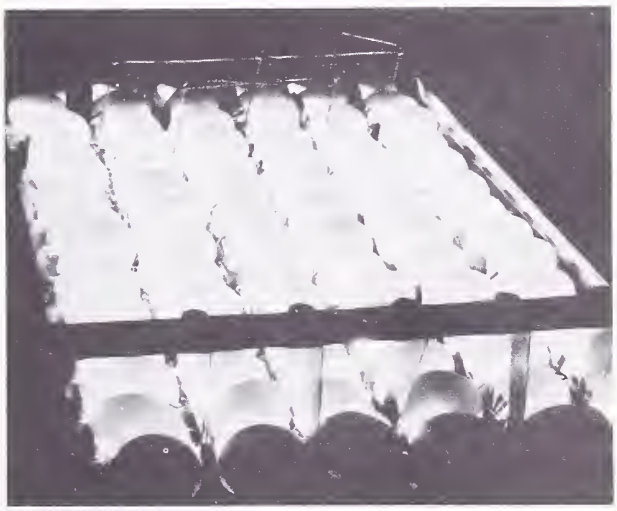

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Figure 4.—Eggs on the flash-candling area of the in-feed conveyor.

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Figure 5.—Translation from six-abreast formation to a single file.

Bloodspot Detector

The bloodspot detector (fig. 6), an improved commercial model, differs from the one used in the original line in that it is more compact, provides greater bloodspot detecting accuracy, requires less adjustment, and is capable of operating at speeds greater than the speed of the line. The egg transport mechanism within the detector was developed in conjunction with the development of the packaging units.

A series of breakout tests conducted by the Department of Agriculture (table 1) showed the improved detector to be 37 percent more effective in the removal of eggs containing bloodspots, ⅛ inch or larger, than a trained grader working at the flash-candler. The detector rejected clear eggs at a rate of 44 per 1,000 eggs examined (4.0 per bloodspot ⅛ inch or larger removed) and the grader rejected clear eggs at a rate of 35 per 1,000 eggs examined (4.4 per bloodspot ⅛ inch or larger removed).

TABLE 1.—*Results of tests employing visual and electronic methods of bloodspot detection* [1]

Means of detection	Number of			Rate of missed bloodspots per 1,000 eggs [2]
	Eggs examined	Eggs rejected	Bloodspots missed [2]	
Visual detection	15, 120	[3] 708	122	8. 07
Electronic detection	15, 120	[4] 870	78	5. 16

[1] Based on the results of broken-out tests conducted under the supervision of AMS, November 1958.
[2] Bloodspots ⅛ inch or larger.
[3] Includes 64 bloodspots smaller than ⅛ inch.
[4] Includes 44 bloodspots smaller than ⅛ inch.

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Figure 6.—Improved bloodspot detector.

In-Line Scales

There are a number of commercial models of in-line scales for continuous weighing of individual eggs, but relatively few that operate accurately at speeds of 20 cases per hour. A commercial model of a low-volume in-line scale was modified to handle the experimental line speed. It was selected because of its adaptability to other features of the experimental line, its simplicity of construction, weighing accuracy, and easy conversion to higher speeds. It was modified by lengthening the scale track to accommodate scales for five size classes. Each of the modified scales is capable of weighing eggs at rates up to 7,200 per hour. The scale units (fig. 7) receive eggs directly from the detector, and eject them automatically at the packaging units. Each scale is adjusted to respond to the minimum weight of one of the size classes (extra large, large, medium, or small [5]). An egg heavier than a scale adjustment depresses the scale beam and closes an electric circuit that activates the ejector mechanism. Instantly the egg is pushed from the track to one of the packaging stations. The larger eggs in the steady stream of eggs are diverted first. The

[5] Scales for jumbo eggs can be installed if volume warrants.

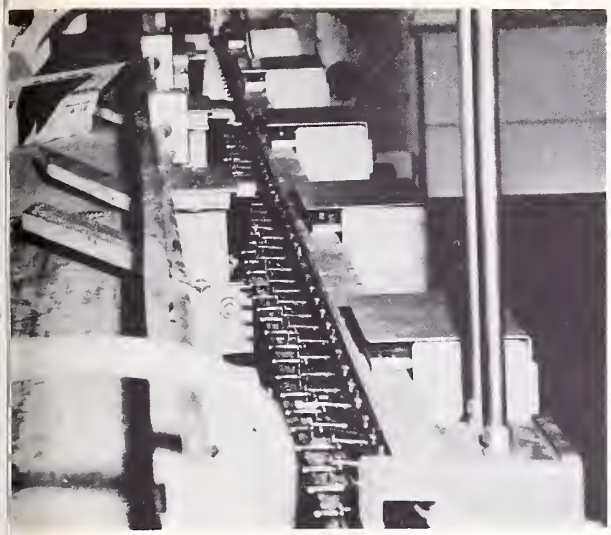

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Figure 7.—In-line scales. Eggs of different sizes are weighed and ejected at different points on the line.

smaller eggs move on to scales adjusted to their respective sizes. Peewee eggs are ejected last without additional weighing, as a cam activates an ejector at the end of the scale track to remove all eggs remaining on the line at that point.

Egg Positioners

The egg positioners (fig. 8) are probably the most unusual feature of the line. Their development and smooth coordination with other components of the line made possible the rapid mechanical manipulation of each egg to assure packaging with its small end down. Three positioning units receive eggs from the extra large, large, and medium scales. The positioning units are 6-inch-

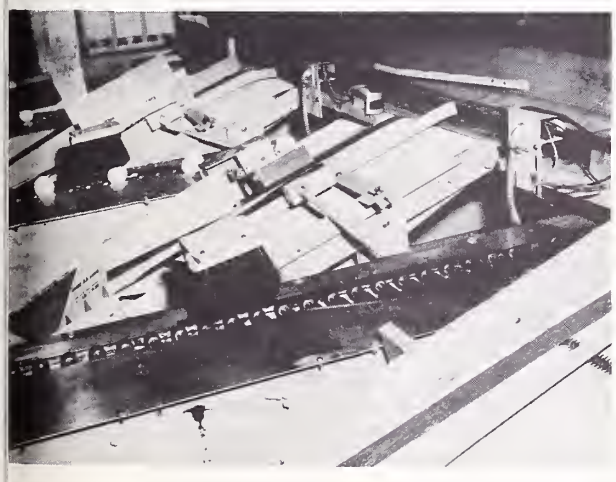

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Figure 8.—Egg positioners with extra large and large eggs moving into position (upper left). In foreground, empty positioner awaiting medium sized eggs.

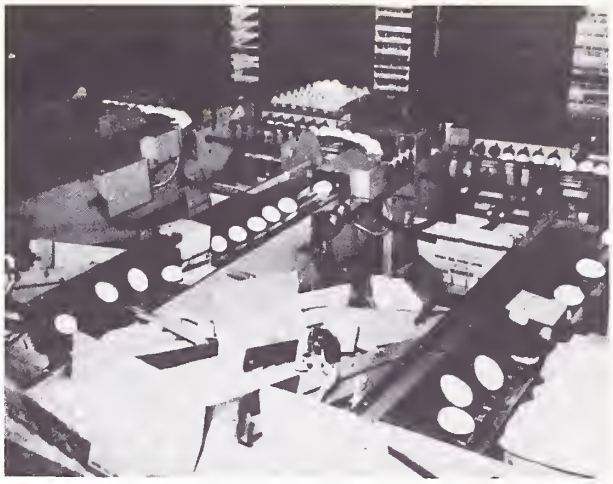

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Figure 9.—Eggs are delivered to the packaging chains (top) with all small ends to the right.

wide conveyors with rubber-covered rotating rollers moving toward each of the three packaging units. The tendency of a rolling egg to move in the direction of its small end was employed in positioning each egg for packaging with its small end down (a "must" for correct packaging of eggs). Eggs delivered to a conveyor with their small ends to the left move to a turning guide at that end of the rollers, reverse their positions (fig. 9), and drift back to the right to join those already in proper packaging position. Continuing toward the packaging unit, they pass a photoelectric cell, which controls their movement onto the J-shaped packaging chain (fig. 9, top center).

As each egg breaks the photo cell light beam, the packaging chain is activated (fig. 10), moving the line of eggs toward the packaging head. Each forward movement is equivalent to the width of an egg.

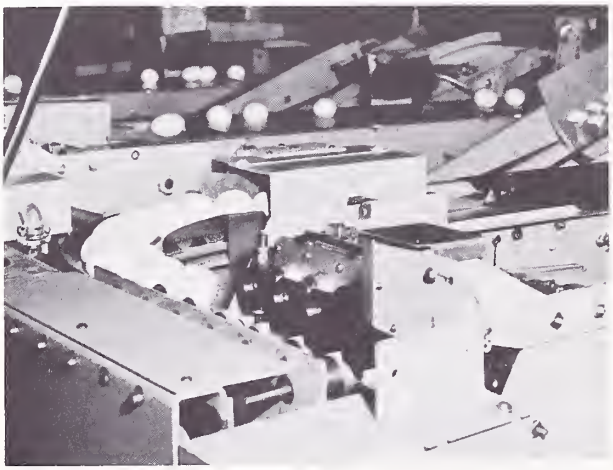

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Figure 10.—Eggs moving into packaging position.

Automatic Packaging Units

Each automatic packaging unit consists of three main components—a packaging assembly (fig. 11), a carton positioning belt (fig. 12), and a magazine-type carton dispensing assembly (fig. 13). Empty cartons are deposited on the carton positioning belts, filled, and moved away automatically.

As a group of eggs move into packaging position on one of the packaging chains, the first egg in line trips the packaging switch, and the vacuum pickup head is activated (fig. 14). As the pickup head moves forward to begin the pickup stroke, a group of six eggs are pushed forward slightly by shallow backup cups that support them as they are grasped by the vacuum cups. The vacuum head then withdraws and carries the six eggs in an arc-shaped stroke to an awaiting carton. At the end of the stroke, a cam lifts the vacuum release levers on the back of the pickup head, releasing the eggs into the carton (fig. 15). The pickup head then returns to its starting position for its next pickup.

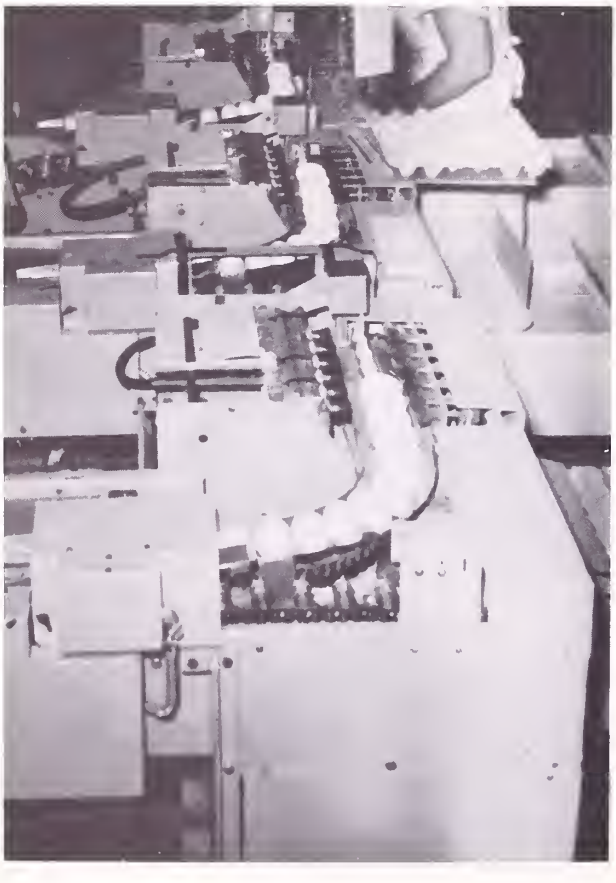

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Figure 11.—The automatic packaging units.

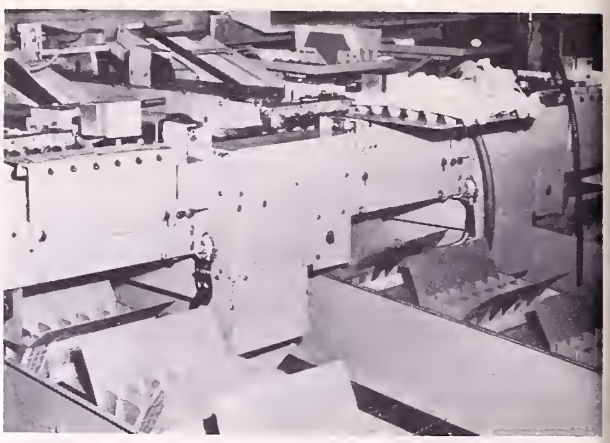

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Figure 12.—Cartons entering packaging assemblies on carton positioning belts.

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Figure 13.—Carton dispensing magazines deposit cartons on the carton positioning belts.

The use of vacuum cups for picking up eggs is not new, but coordination of the pickup stroke with automatic egg and carton positioning is a new development. Proper alinement of eggs, action of the holding cups, and proper functioning of vacuum cups were some of the most sensitive factors in the new line. Poor alinement resulted in the pickup of less than six eggs, or in dropped eggs. Accurate alinement through careful, regular adjustment and servicing effectively reduced trouble from this source.

Empty cartons are positioned by lug belts, which receive them from dispensing magazines

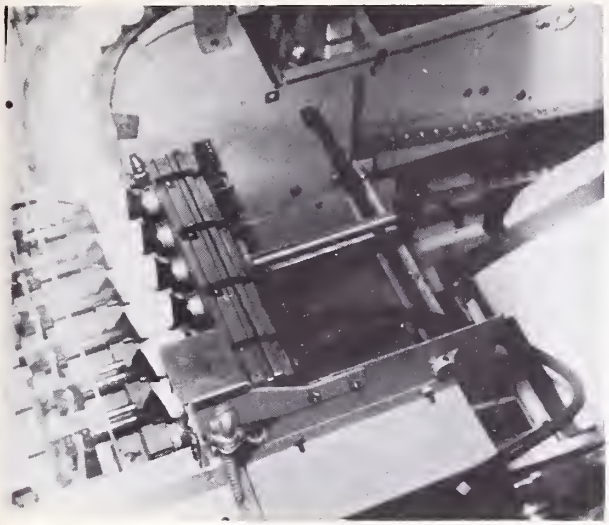

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Figure 14.—Vacuum cups grasping six eggs on vacuum head pickup stroke.

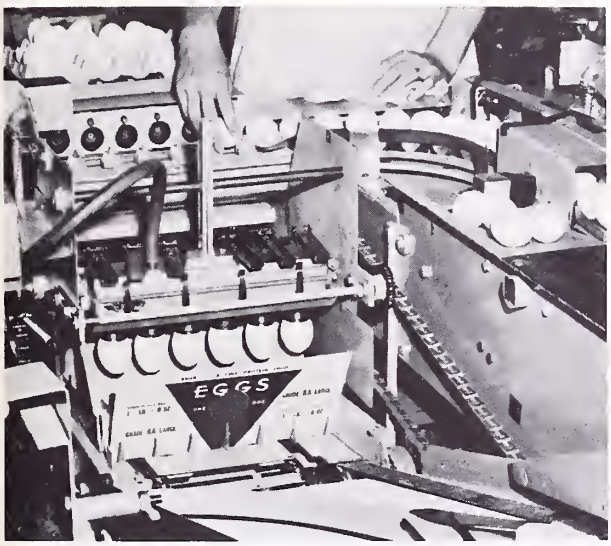

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Figure 15.—Vacuum head completing its packaging stroke.

and move them into packaging position in alternating 10-inch and 2-inch movements.[6] Simultaneously with the 10-inch movements, the filled cartons are pushed onto the carton removal belts (fig. 9) and replaced by empty cartons from the carton dispensing magazines at the opposite end of the positioning belts (figs. 12 and 19).

The dispensers are synchronized with the belt movements, to release cartons from the magazines

[6] The packaging and carton positioning assemblies can be adapted to single-flap cartons, molded pulp cartons, or filler-flats.

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Figure 16.—Traffic control brakes hold cartons on the inclined belts until cartons on main belt (foreground) have passed.

as space is made available on the positioning belts. The magazines are loaded manually.

In the development of the carton dispensing and positioning assemblies a problem of undependable carton release and positioning was encountered, due to the tendency of cartons to hang up on the sides of the magazine. This difficulty was eliminated by tapering the magazines to guide the descent of the falling cartons. Another problem involved adequate carton flap clearance for the vacuum head as it came into position to release six eggs. It was solved by installing a depressor to hold the carton flaps out of the path of the vacuum head.

The removal belts deliver cartons to the main carton belt, where interference between cartons is prevented by traffic control brakes which hold cartons on the removal belts until the main belt is clear (fig. 16).

Carton Setup Equipment

Empty cartons are formed in a standard setup machine and pushed by the action of the machine onto a temporary storage rack (figs. 17 and 19). The machine is loaded manually by placing bundles of 25 cartons on a feeder rack. Once started, the machine continues to set up cartons as long as a reserve supply remains in the feeder rack. By frequent loading, it can be made to form any number of cartons without restarting. An oscillating lifter within the machine raises the formed cartons to the level of the top shelf of the carton storage rack.

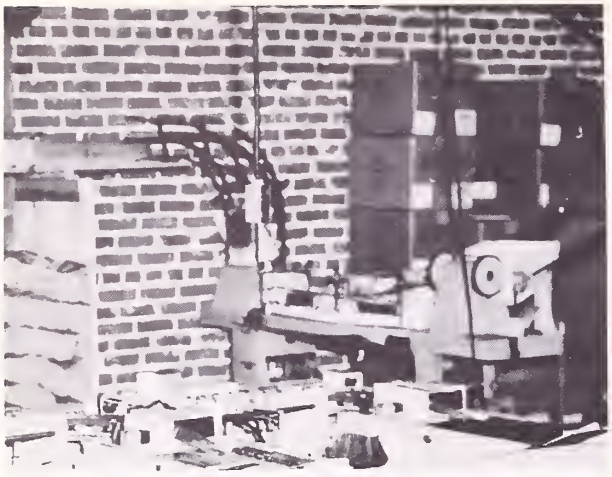

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Figure 17.—Carton setup machine with delivery guide to storage rack for madeup cartons.

Storage Shelves

Storage shelves for empty cartons and filler-flats were installed along the wall nearest the automatic carton dispensers and at the small and peewee packaging stations (figs. 18 and 19). Shelves for undergrade eggs removed from the in-feed conveyor are the same as those used for the original line, except that "ports" for moving filler-flats of eggs to the packing station are provided (fig. 3). A shelf was installed over the undergrade shelves for passing empty cases from the line loading station to the packing station.

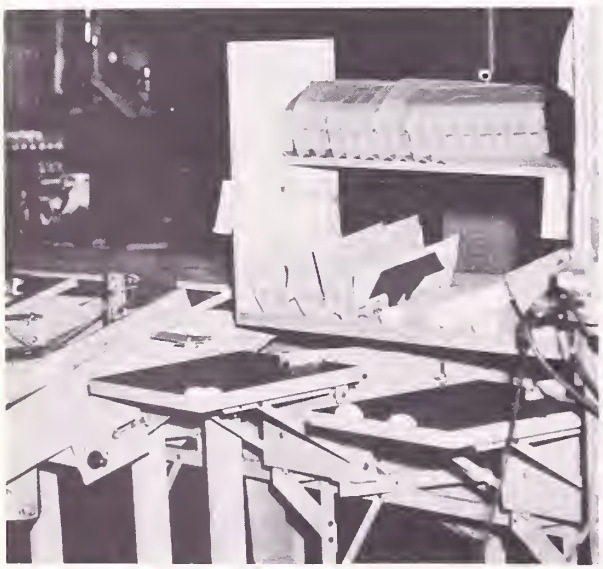

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Figure 18.—Small and peewee egg packaging station, where these eggs are packaged manually.

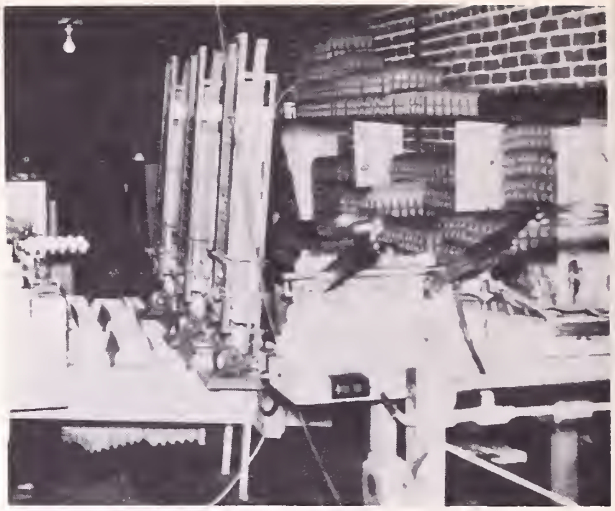

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Figure 19.—Carton storage shelves, makeup machine (right), and dispensing magazines (center).

Egg Trays for Manual Packaging

Manual packaging equipment consists of three simple belt and tray assemblies for receiving small and peewee eggs (fig. 18), and eggs rejected by the bloodspot detector. Eggs are delivered by short canvas belts to the receiving trays, where they are accumulated for packaging in cartons or filler-flats. Manually cartoned small eggs are placed on the main carton belt by hand. The manual packaging trays can be replaced by automatic units, as volume warrants.

Carton and Filler-Flat Packing Equipment

The principal components of the carton and filler-flat packing equipment are the same as, or similar to, those of the original units. They differ

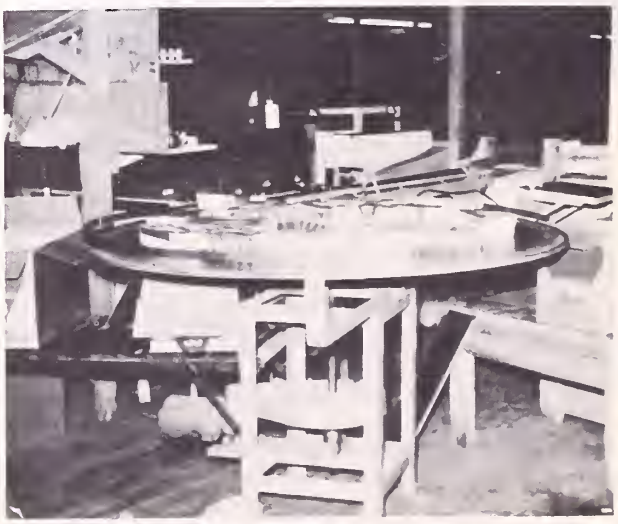

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Figure 20.—Carton closer and packing table.

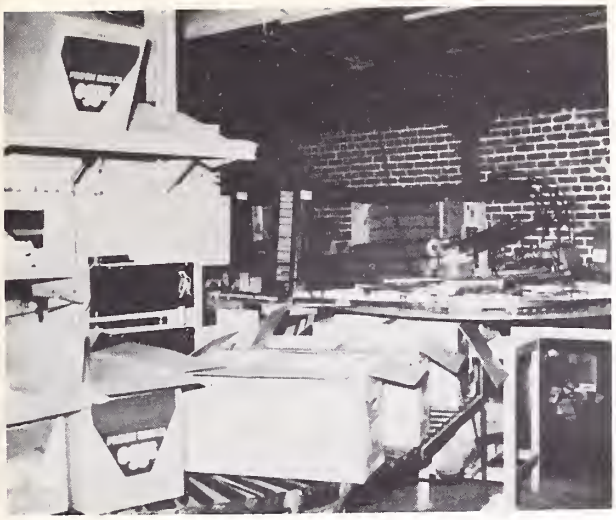

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Figure 21.—Carton-packing (right) and flat-packing (left) stations at rear of flash-candler. At upper left is the empty case shelf.

mainly in their location and direction of product flow. The main cartoned-egg belt bridges the positioning units in carrying the eggs to the carton closer and the packing table. The closer is a standard type which folds and closes the carton flaps automatically as a chain belt carries the cartons through a closing tunnel and onto the packing table (fig. 20).

The packing table is a standard 5-foot rotating table which delivers the cartons to a position within reach of the carton packer. The filler-flat packing station (fig. 21) is located next to the carton packing table, at the rear of the line loading station.

Equipment Speeds and Capacities

The grading and weighing equipment is capable of handling 7,200 eggs per hour of continuous running. The flash candler conveyor holds 264 eggs in 44 rows of 6 when loaded to capacity. Space for 20 rows of eggs is provided at the loading end of the conveyor, for receiving ungraded eggs and for surface inspection, and space for 10 rows of eggs is available on the flash-candling area for detection of blind checks and interior defects. The eggs on the conveyor are moved toward the discharge end 20 times each minute. This rate allows the operator 1 minute for filling empty spaces on the rollers before they reach the flash-candling area and ½ minute for examination for interior defects. Between forward movements, all eggs on the flash-candling area are rotated to set their contents in motion. The output of the flash-candler conveyor (and of the entire line) varies according to the ability of the operator at this station to keep it loaded.

The operator's work station has sufficient space for a 30-dozen case, a single stack of empty filler-flats, and a container for smashed eggs. Shelves over the conveyor have a combined capacity of 30 filler-flats of eggs in stacks of 3 filler-flats each. Only about half of this capacity was used during the study. The empty case shelf over the conveyor (to the bulk pack station) has space for two empty cases. The singulator is synchronized with the intermittent forward motion of the main conveyor.

The bloodspot detector, operating 120 times each minute, examines the eggs individually, as they move through it in single file at a rate equal to the output of the line. The blood reject unit operates as often as necessary to remove eggs containing blood. The scales and their automatic ejectors operate only with the passage of an egg heavier than a scale setting, but each scale can weigh up to 120 eggs per minute when eggs happen to be all in one size class. The peewee egg ejector operates with the passage of each pusher bar on the track, to eject any eggs not removed by the scale units.

Each positioning conveyor operates continuously at a rate of 240 rollers per minute to receive a maximum of 120 eggs per minute from 1 of the sizing unit ejectors.

Each automatic packaging unit can package eggs at a rate of 10 dozen per minute. Empty carton delivery is synchronized to equal the demand, and each carton chute holds 20 cartons,[7] in addition to 4 in reserve on the carton positioning belt.

The capacities of the blood reject, small, and peewee egg trays vary according to the egg sizes—approximately 45 blood rejects and 60 small or peewee eggs.

All carton belts are adequate for the removal of cartoned eggs from every packaging station, and the capacity of the automatic carton closer exceeds that of the main belt.

The carton packing table accommodates a safe maximum of approximately 25 cartons. The carton and filler-flat packing benches are large enough to hold nine cases.

The total capacity of the empty carton storage shelves is approximately 1,000 cartons. The 75-carton accumulating capacity of the upper shelf is equivalent to one loading of the carton-forming machine. A 2-foot space at one end of the upper shelf is devoted to storage of from 24 to 36 cartons for small eggs. The shelves over the small and peewee packaging trays hold 30 cartons.

Filler-flat storage space at the packaging stations is sufficient for at least a full day's run.

[7] Commercial units now have increased the reserve capacity of the chutes by extending them to a packaging material supply mezzanine or second floor, and makeup machines are now available that will form and supply cartons on demand.

The floor space available at the carton-forming machine is sufficient for 2,500 cartons of each size (extra large, large, medium, and small) and 20 empty carton boxes.

The gravity conveyor supplying the line holds 20 cases. Since the conveyor at the packing table is kept empty by a full-time crew in the cooler, its capacity is not involved.

Analysis of Manual Operations

The manual operations necessary to the operation of the automatic packaging line are: (1) Egg transferring and flash candling (including the necessary packing materials handling and the packaging of undergrade eggs); (2) manual packaging (blood reject, small, and peewee eggs); (3) carton and filler-flat packing; (4) carton forming and storing; and (5) carton supplying. The egg transferring and flash candling operation is performed by a worker whose duties do not permit leaving the station. The packing and carton forming and supplying operations and most of the manual packaging operations are performed by a worker who walks between work stations as necessary. A third operator tends the packaging equipment [8] and assists with the manual packaging operations if necessary.

Empty filler-flats are distributed to the manual packaging stations by the carton packer and the packaging unit tender.

Full cases are placed on the conveyor supplying the line by the pallet transporter operator who brings the eggs from the cooler.

Full Case Supplying

Palletloads of 30 cases of eggs are brought from the cooler by pallet transporter, placed next to the gravity conveyor supplying the line, and transferred to the conveyor in 15-case lots. The labor for operating the pallet transporter is not included in the labor requirement computations.

Egg Transferring and Flash Candling

Full cases of eggs are pulled into position from the gravity conveyor, and the eggs are transferred to the in-feed conveyor with a multiple egg lifter, 30 at a time (fig. 3). Empty filler-flats are stacked on the bench or on the reject shelf. Empty cases are placed on the empty case transfer shelf or pushed under the carton closer to the blood reject packaging tray. Approximately 97 percent of the eggs are transferred directly to the flash candler, and the remainder are transferred in the filler-flats to the reject shelf and used to replace eggs removed during grading.

As the eggs move toward the underlit area, they are examined for stained, dirty, misshapen, or checked shells. Eggs found to have these defects are removed and placed in the filler-flats on the reject shelf. As the eggs pass over the underlit area, they are examined for obvious interior defects and for checked shells not readily visible without interior lighting. Defective eggs are removed and placed in filler-flats on the reject shelf, and the empty spaces on the conveyor are filled from the reserve supply maintained on the same shelf. Occasional eggs in the jumbo size class are handled in a similar manner. The work elements are performed in the following order:

1. Open and position full case.
2. Remove two empty filler-flats.
3. Transfer 60 eggs to conveyor (2 groups of 30 eggs each).
4. Remove two empty filler-flats.
5. Examine eggs and remove undergrade and reject eggs.

After the first 2 elements are completed, the next 3 elements are repeated in the same sequence for the remaining 300 eggs (10 filler-flats), except that after the last 2 empty filler-flats are removed, the empty case is closed and disposed of before the eggs are examined.

The worker who places eggs on the line and flash-candles them paces the operation to the speed of the in-feed conveyor, placing eggs on the conveyor as soon as space for 60 eggs is available, and compensating for variations in time required to handle empty cases and filler-flats by varying the quantities of eggs inspected. A single transfer of 60 eggs may be delayed until several extra rows of empty rollers have moved into position, but the last 60 eggs in each case must be transferred to rollers near the end of the conveyor, in order that no unexamined eggs pass beyond the underlit area while the operator is handling cases.

Manual Packaging

Undergrade, reject, jumbo, small, and peewee eggs are packaged manually at the flash candler and the packaging trays. Eggs removed from the flash candler are packaged in filler-flats on the reject shelf and pushed through the openings in the rear partition to the filler-flat packaging sta-

[8] A crew of three operators was used during the study because of the concern over excessive breakage that could develop if one of the mechanical packing units failed. However, analysis of these data indicates that loss due to breakage may not warrant a third operator when an adequate equipment adjustment and maintenance schedule is followed carefully (app., p. 15).

tion (fig. 3). Empty filler-flats are obtained from a small stack maintained on the shelf.[9]

Blood reject eggs are packaged in filler-flats on a small shelf at the reject tray. The carton packer and the packaging unit tender each package a part of the eggs.

Small and peewee eggs are packaged on one of the shelves at the small and peewee packaging trays (fig. 18). Cartons, for the small eggs, and filler-flats, for the peewee eggs, are transferred from the upper shelf as needed. Cartoned eggs are pushed from the packaging shelf onto the main carton belt. Peewee eggs usually occur infrequently, and may often be allowed to accumulate in the tray for an hour or more before packaging.

Carton and Flat Packing

Empty cases for cartons of extra large, large, and medium sizes are transferred from the case transfer shelf to the roller conveyor (fig. 21) and positioned so that the predominant sizes can be packed in the cases nearest the rotating packing table. Small eggs are packed on the opposite side of the table. Full cases are moved from the packing table to the cooler by gravity conveyor. Cases for excess empty filler-flats are obtained from a supply maintained at the rear of the packing station. Cartons are packed when from 15 to 20 have accumulated on the table. Small eggs are often allowed to remain on the table until it is necessary for the packer to pass the small egg packing bench on the way to another work station. Filler-flats of eggs are packed in 30-dozen cases as they accumulate.

Carton Forming and Carton Storing

Cartons are removed from the carton boxes and placed in the setup machine in bundles of 25. After they are formed and pushed onto the storage rack by the setup machine, the extra large, large, and medium egg cartons are transferred in groups of about 12 to the lower shelf, or to the carton supply magazines, and the cartons for small eggs are stacked at one end of the top shelf.

Carton Supplying

Cartons are supplied to the automatic dispensing magazine and the small egg packaging station by hand. Stacks of about 12 cartons are transferred from the storage rack to the magazines or the shelf over the small egg packaging tray when the reserve supplies are nearly exhausted.

Packaging Unit Tending and Unscheduled Cleanup

The packaging unit tender monitors the operation of the packaging and carton positioning equipment, prevents breakage in case of vacuum pickup failure, removes smashed eggs, and manually fills empty carton cells in incompletely filled cartons (during the tests, the vacuum cups of the packaging units sometimes stuck and failed to package an egg). The carton packer watches the carton conveyor belts and the packing table for breakage and carton jams.

When egg breakage is detected at the packaging units, the packaging unit tender cleans the machine immediately (without stopping it, if possible). If it is necessary to stop the machine, the carton packer may be available for assistance. Occasional breakage at other points on the line is usually cleaned up by the carton packer without stopping the line. Unscheduled cleanup necessary during the study is included in the labor requirements for the machine tending operations.[10]

Production Rates and Crew Sizes

The rated production capacity of the line is 20 cases per hour of continuous operation. The production rate depends on the percentage of undergrade eggs removed and replaced by the flash candler, and the amount of down time necessary for cleanup. During this study, 3 workers operated the line at an average production rate of 17.8 cases per hour (5.9 cases per worker per hour).

The line may be operated at reduced production rates by two workers. Under these conditions, the carton packer would serve as packaging unit tender in addition to performing his other duties. Because of his frequent proximity to the packaging units, most malfunctions could be detected quickly.

Near-capacity production rates can be maintained by a two-man crew if labor requirements are reduced by equipment modification as follows: (1) Combining carton forming, supplying, and storing into one mechanized operation; (2) relocating the carton forming and carton packing stations (to reduce walking distances); (3) enlarging the manual packaging trays and shelves (to reduce the frequency of walking between them and other points on the line); and (4) lengthening the loading and underlit areas of the flash candler (to increase time available for grading).

Economical operation by any crew requires effective equipment maintenance and egg quality control. Poorly maintained equipment is subject to repeated failures which cause excessive egg breakage and prevent continuous operation. Poor shell conditions or high incidences of cracked shells also cause excessive breakage. Irregular quality requires removal and replacement of undergrade eggs at rates beyond the operator's capabilities, causing production losses or poor workmanship.

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[9] The labor requirements for this packaging operation are included in the flash-candling labor.

[10] Procedures for scheduled cleanup are furnished in the cleaning and maintenance schedule (app., p. 15).

Labor Requirements and Total Costs

The total labor requirement for grading and packing 100 cases of eggs of the uniformly fine quality and size distribution packaged during the study is 16.97 man-hours (table 2). Three workers devote their full time to the operation of the line and one worker devotes 0.14 man-hour to supplying full cases of eggs to the line. The elapsed time is 5.61 hours. All equipment is considered in use for the full elapsed time.

TABLE 2.—*Labor required for flash-candling, packaging, and packing 100 cases of eggs at the automatic packaging line with 3-man crew*

Operation [1]	Flash candler	Carton packer	Packaging unit tender	Total crew
	Man-hours	*Man-hours*	*Man-hours*	*Man-hours*
Full case supplying	------	------	------	[2] 0. 14
Egg transferring and flash candling:				
Handling full cases	0. 22	------	------	. 22
Handling empty packing materials	. 73	------	------	. 73
Placing eggs on conveyor	1. 55	------	------	1. 55
Flash candling eggs	3. 09	------	------	3. 09
Manual packaging	------	0. 30	0. 42	. 72
Carton and flat packing	------	1. 97	. 09	2. 06
Carton forming and storing	------	1. 28	------	1. 28
Carton supplying	------	. 72	------	. 72
Walking	------	. 75	. 15	. 90
Machine tending and unscheduled cleanup	------	. 13	4. 94	5. 07
Set up and clear machine	. 02	. 02	. 01	. 05
Wait (unproductive)	------	. 44	------	. 44
Total	5. 61	5. 61	5. 61	16. 97
Total labor	---------- 16.97 man-hours.			
Elapsed time	---------- 5.61 hours.			

[1] Work elements performed in connection with various operations are listed in the appendix (table 5).
[2] The full case supplier has duties at other locations within the plant.

Labor Requirements

The egg transferring and flash-candling operations pace the operation of the line. The flash-candler spends 4.64 hours per 100 cases in transferring and examining eggs, 0.95 hour handling full cases and empty packing materials, and 0.02 hour disposing of accumulated trash while the last eggs loaded at the end of a shift are clearing the packaging units.

The carton packer performs all of the carton packing and empty carton supplying operations. The packaging unit tender assists with the packaging and packing of blood rejects. Both workers watch the packaging units and the carton belts for breakage. They also distribute packing materials and clean up at the beginning and end of each shift.

Of the total labor, 3.79 man-hours (22.2 percent) is grading and manual packaging labor. Carton and flat packing operations total 2.06 man-hours (12.1 percent of total labor). Egg transferring, including handling the full and empty cases, requires 2.50 man-hours (14.7 percent of total labor). Empty carton forming, storing, and supplying labor totals 2.00 man-hours (11.8 percent of total labor). A total of 5.07 man-hours per 100 cases (29.2 percent of total labor) was devoted to machine tending and unscheduled cleanup during the study (4.94 hours by the packaging unit tender, and 0.13 hour by the carton packer). Machine down time for cleanup totaled 1.4 percent of the elapsed time. A total of 0.9 man-hour per 100 cases (5.3 percent of the total labor) was spent walking, and 0.44 man-hour per 100 cases was unproductive. The machine time required for grading and packaging 100 cases, when 3 percent of the eggs are removed by the flash-candler and all eggs removed from the flash-candler conveyor are replaced without stopping the machine, is 4.85 hours.

Total Costs of the Automatic Packaging Operations

The labor costs for the automatic packaging operation, at the assumed wage rate of $1.68 per hour (app., p. 15), are $28.51 per 100 cases (16.97 man-hours at $1.68 per hour). Equipment costs, at an annual production rate of 35,651 cases, total $19.97 per 100 cases (5.61 machine-hours at $3.56 per hour; app., table 4). The scales and packaging equipment ownership and operating costs of $8.07 per 100 cases are 40.4 percent of the total equipment costs. Bloodspot detector rental fees ($7.24) are the next largest item, constituting 36.3 percent of the total equipment costs. Flash-candling equipment costs ($2.47) are 12.3 percent of the total, and the carton supplying and packing equipment costs ($2.04) are 10.2 percent.

The total labor and equipment costs are $48.48 per 100 cases. Of the total costs, 58.8 percent are for labor and 41.2 percent for equipment. Manual packaging costs are $1.29 (4.5 percent of labor costs, or 2.7 percent of total costs). Grading and manual packaging labor costs ($6.32) are 22.2 percent of total labor costs, and 13.0 percent of total costs.

Comparison of Costs of Manual and Automatic Packaging Operations

The costs of grading and packing 100 cases of presized eggs of 80 percent A quality or better, using the manual packaging methods and equipment described in Marketing Research Report No. 239, ranged from $42.86 to $59.27, depending on the quality of the eggs and the grading methods employed. A basis for their comparison with the costs of the automatic packaging operation is established by adding the costs of an efficient sizing operation to the costs of each of the manual grading operations (table 3).

Summary of Costs of Manual Packaging Operations

Total costs were highest ($72.02 per 100 cases) when the eggs were hand candled after flash candling and electronic bloodspot detection. Grading labor costs, including the cost of manual packaging, totaled $32.76 (19.50 man-hours at $1.68 per hour). Of the total costs of $72.02 per 100 cases, $12.75 were for sizing and $59.27 were for other labor and equipment. Bloodspot detector rental fees were $7.26 (see footnote, table 3).

When the eggs were hand candled and the bloodspot eggs removed manually, the total costs were $58.75 per 100 cases. Sizing cost $12.75 and other labor and equipment $46.00. Grading labor costs, including the cost of manual packaging, were $28.53 (16.98 man-hours at $1.68 per hour).

When hand candling was omitted and grading limited to flash candling and electronic bloodspot detection, total costs were $55.61 per 100 cases. Sizing costs were $12.75 and other labor and equipment costs were $42.86. Grading and manual packaging labor costs were $15.79 (9.40 man-hours at $1.68 per hour). Bloodspot detector rental fees were $7.26.

Comparison of Costs

The total costs of the automatic packaging operation, $48.48 per 100 cases, are less than the costs of any of the three manual packaging operations, in spite of greater equipment costs. Electronic bloodspot detection did not significantly reduce labor requirements for hand candling. Total costs for hand candling were increased $13.27 per 100 cases when the detector was used along with hand candling for other defects. When hand candling was omitted, and grading limited to flash candling and electronic bloodspot detection, reductions in labor costs were 55 percent greater than the increases in equipment costs (as compared with hand candling), and the total costs were reduced by $3.14 per 100 cases. In-line weighing and automatic packaging, by eliminating most of the manual handling of individual eggs, further reduced labor costs. The total costs of the automatic packaging operation were $7.13 less per 100 cases than the total costs of flash candling and electronic bloodspot detection, and $10.27 less per 100 cases than the costs of the all-manual method.

TABLE 3.—*Comparative labor and equipment costs for sizing, grading, and packing 100 cases of eggs by manual methods and with automatic packaging equipment*

Method and equipment	Crew size	Elapsed time	Labor and equipment required		Labor and equipment costs		
			Labor	Equipment	Labor	Equipment	Total
	Number	*Hours*	*Man-hours*	*Machine-hours*	*Dollars*	*Dollars*	*Dollars*
Manual packaging: Hand candling and manual bloodspot removal [1]	13	2. 15	24. 62	2. 15	53. 08	5. 67	58. 75
Manual packaging: Hand candling, after flash candling and automatic bloodspot removal [1]	6	5. 65	28. 82	5. 65	60. 14	[2] 11. 88	72. 02
Manual packaging: Flash candling and automatic bloodspot removal [1]	4	5. 65	19. 32	5. 65	44. 18	[2] 11. 43	55. 61
Automatic packaging: Flash candling and automatic bloodspot removal	3	5. 61	16. 97	5. 61	28. 51	[3] 19. 97	48. 48

[1] Manual packaging operations evaluated in Marketing Research Report No. 239. Figures include the following costs for separate sizing operation: Assumed initial investment, $500. Costs per 2,000 hours of operation: Depreciation, $60, interest, taxes, and insurance, $32.50, maintenance, $75, power, $5. Total annual ownership and operating costs, $172.50. Total equipment costs, 11.97 machine-hours at $0.086 per hour, $1.03. Labor costs in excess of costs for transferring eggs from baskets to filler-flats and cases, 8.37 man-hours per 100 cases at $1.40 per hour, $11.72. Total additional labor and equipment costs for sizing, $12.75 per 100 cases.

[2] Electronic detector rental, $7.26; flash-candler, $1.10.

[3] Electronic detector rental, $7.24; flash-candler, $2.34; scales and automatic packaging equipment, $7.61.

Conclusions

The successful operation of mechanized egg sizing, grading, and packaging equipment developed by the Department of Agriculture has demonstrated that, although equipment cost is high, eggs of uniformly fine quality can be prepared for market for 10 cents per case less than by many manual methods. As additional experience is acquired in the use of the new equipment, even greater economies can be expected from the use of improved commercial models of the packaging and bloodspot detecting equipment, and from multiunit combinations served by common carton supplying and packing operations.[11]

Economical operation of automatic equipment requires regular service and preventive maintenance. Effective utilization requires that it be used only for handling eggs of uniformly fine quality, and that operators and maintenance personnel be carefully trained.

Although efficient use of this type of equipment is restricted to operations with closely supervised quality control programs, possible savings to the industry are unusually significant. Approximately 25 percent of the estimated 4.8 billion dozen eggs sold off U.S. farms in 1959 fell into this category. The sizable marketing cost advantages now afforded to progressive producers and the packing plant operators that serve them can be expected to lead to further improvements in the general level of egg quality.

Recommendations

Management should carefully evaluate the effectiveness of its procurement program for quality eggs and its ability to provide necessary maintenance facilities before making a decision on the installation of automatic equipment. A careful check should first be made of the incoming egg quality over a period of several months. If automatic equipment is installed, extensive egg quality tests should be continued and equipment performance should be evaluated daily. Eggs from producers who cannot be depended upon to deliver uniformly fine quality should be relegated to manual handling involving less expensive equipment.

Maintenance personnel should be trained by factory maintenance representatives. It is desirable that the maintenance crew selected to service the equipment assist with the installation. A well-equipped shop with adequate working space should be maintained and stocked with replacement parts. A day-to-day machine operating record should be maintained to show machine operating time, down time and its causes, and corrective action taken. The record should be analyzed periodically for evidence of a pattern of failure of individual parts. Once a pattern has been established, each part, or group of similar parts, should be replaced before failure. Preventive maintenance will be most effective if a production record is kept for each of the major components. A member of the maintenance crew should be on duty within the plant at all times during operation of the line (one of the operating crew may qualify for this if a regular member of the maintenance crew is on call).

The operating crew should be responsible for any cleaning necessary during operation of the line. If at all possible, soiled components should be cleaned without stopping the line, but equipment failures should not be neglected in an attempt to keep the line operating. The cleaning and maintenance schedule (app., p. 15) must be followed closely and implemented with knowledge gained from operating the line.

Consideration should be given to a 2-shift operation, to take advantage of the lower bloodspot detector rental rates for annual volumes over 20,000 cases. Detector rental rates for production in excess of 20,000 cases annually were 5 cents per case at the time of this study as against 10 cents for the first 10,000 cases.

The layout and design of the prototype line shown in this report should not be considered as a model. The layout was designed to utilize available plant space in an existing commercial operation. Any of the currently available models of the equipment can be arranged more effectively in a more suitable space.

In selecting the auxiliary equipment and packing materials to be used with the automatic equipment, consideration should be given to the amount and nature of the manual handling which can be eliminated. Mechanized equipment can seldom meet the needs of a plant that does not take advantage of the capabilities of the equipment.

[11] According to latest estimates, single or multiunit installations are in operation in more than 35 plants.

Appendix

Equipment Costs

The equipment ownership and operating costs are computed on the basis of an elapsed time requirement of 5.61 hours for each 100 cases of eggs graded and packed. The initial costs are prorated over the expected life of each item of equipment, at a rate of 2,000 hours of use per year. The interest, insurance, tax, and power rates prepared for an earlier study of mechanization of egg grading and packing[12] are used to provide a meaningful comparison of equipment costs. Maintenance costs are based on the labor requirement for servicing the equipment according to the cleaning and maintenance schedule (app., p. 15) and an allowance for the cost of replacement parts. Bloodspot detector rental fees are determined on a sliding scale; the hourly cost for the detector varies with the annual volume (first 10,000 cases at 10 cents per case, next 10,000 at 8 cents, and all over 20,000 at 5 cents). The rental costs (table 4 on page 16) are based on an annual volume of 35,651 cases.

Labor Costs

The hourly wage rate of $1.68 is the same as that used in an earlier study.[12] It includes a base wage rate of $1.56 per hour, and a prorated portion of the costs of vacation pay, insurance, pensions, State unemployment compensation, F.I.C.A., workmen's compensation, and personal equipment. It does not include management costs.

Cleaning and Maintenance Schedule for Automatic Grading and Packaging Line

Daily

1. Remove egg meat from moving parts or vacuum cups as soon as possible after breakage occurs.[13]
2. Remove and clean vacuum head manifolds after each shift. Inspect vacuum valve springs and replace weak springs as necessary.
3. Clean underlighting glass screen (in-feed conveyor) after each shift or after any period during which extensive breakage occurs.
4. Check contact points on bloodspot detector memory disc for free, positive action.

Weekly

1. Dry clean in-feed roller conveyor rollers with wire brushes.
2. Blow down (compressed air) all roller conveyor linkage on packaging and in-feed units.
3. Blow down (compressed air) packaging units and in-feed conveyor and remove all adhering egg meat.
4. Vacuum clean (do not blow) scale conveyor chain and scale platforms. Remove adhering egg meat carefully and apply light coat of "white" oil and wipe clean.
5. Inspect all drive chains and belts for slack; adjust or replace as necessary.
6. Check scales for weight accuracy. Wash bearing points of sluggish or sticking scales with alcohol. Allow to dry before assembling.
7. Apply one drop of light oil to each recoil plunger rod on packaging unit vacuum heads.
8. Adjust packaging unit clutches to keep slippage at a minimum.

Semimonthly

1. Replace all valve springs in vacuum heads on packaging units. Inspect all new springs carefully for proper seating. (If flex points on old springs show sufficient life that removal is not warranted, this period can be extended if a safety margin is provided.[14]

Monthly

1. Apply *light* application of "white" oil with small brush to all drive and roller conveyor chains (do not lubricate carton transport chain).
2. Apply *light* application of gear lubricant to all "zerk" fittings on system. Replace plugged fittings and inspect bearing points for binding or excess play.
3. Apply *one* drop of "white" oil on egg ejector bearings on egg scale conveyor chain.
4. Apply two or three drops of light machine oil to all small motor bearings.

Quarterly

1. Replace detector light globe.[15]

Annually

1. Lubricate main drive and blower motors with lubricant specified by manufacturer. Important: *Do not over-lubricate.*
2. Flush gear boxes and refill to operating level with standard auto transmission lubricant.

[12] Hamann, John A., Winter, Evans R., Stoyanoff, Robert, and Hester, O. C., "Electronic Bloodspot Detection in Commercial Egg Grading." U.S. Dept. Agr., Mkt. Res. Rpt. No. 239, 65 pp. illus. 1958.

[13] Immediate use of one of the packaging head vacuum hoses has proved very effective.

[14] The springs used in commercial models are of more durable material, and longer life may be expected.

[15] Replacement is provided in detector rental contact.

TABLE 4.—*Ownership and operating costs of grading, packaging, and packing equipment, based on 2,000 hours annual use and an annual volume of 35,651 cases, automatic packaging line*

Kind and amount of equipment	Initial cost [1]	Ownership Cost						Operating Cost			Total annual cost	Total hourly cost
		Expected life	Depreciation [2]	Interest [3]	Insurance and taxes [4]	Rent	Total	Power [5]	Maintenance	Total		
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1 flash candler-conveyor and singulator	2, 675. 00	8. 3	321. 00	66. 88	107. 00	----------	494. 88	158. 73	200. 00	358. 73	853. 61	0. 427
1 30-egg spring lifter	14. 85	1. 0	14. 85	. 37	. 59	----------	15. 81	--------	10. 00	10. 00	25. 81	. 013
1 electronic bloodspot detector	----------	--------	--------	--------	--------	2, 582. 55	2, 582. 55	([6])	----------	--------	2, 582. 55	1. 291
4 egg scales	1, 000. 00	8. 3	120. 00	25. 00	40. 00	----------	185. 00	--------	----------	--------	185. 00	. 093
3 automatic packaging units	7, 500. 00	8. 3	900. 00	187. 50	300. 00	----------	1, 387. 50	[7] 44. 14	[8] 1, 000. 00	1,044. 14	[9] 2, 431. 64	1. 216
1 vacuum pump and tank assembly	200. 00	8. 3	24. 00	5. 00	8. 00	----------	37. 00	--------	----------	--------	37. 00	. 019
3 carton dispenser assemblies	304. 70	8. 3	36. 56	7. 62	12. 19	----------	56. 37	--------	----------	--------	56. 37	. 028
3 manual packaging tray assemblies	900. 00	8. 3	108. 00	22. 50	36. 00	----------	166. 50	--------	----------	--------	166. 50	. 083
1 carton belt and drive assembly	225. 00	8. 3	27. 00	5. 63	9. 00	----------	41. 63	[10] 48. 72	20. 00	68. 72	[10] 110. 35	. 055
1 carton closer and packing table	----------	--------	--------	--------	--------	324. 00	324. 00	([11])	25. 00	25. 00	349. 00	. 175
1 carton setup machine	----------	--------	--------	--------	--------	264. 00	264. 00	3. 50	----------	3. 50	267. 50	. 134
Gravity conveyors, shelves and benches	209. 00	8. 3	25. 08	5. 23	8. 36	----------	38. 67	--------	20. 00	20. 00	58. 67	. 029
Total	----------	--------	--------	--------	--------	----------	----------	--------	----------	--------	7, 124. 00	3. 563

[1] 1958 prices, including installation, but not transportation.
[2] 1 percent per month on all equipment except spring lifter.
[3] 5 percent of average investment (computed at 50 percent).
[4] 4 percent of initial investment.
[5] 1.45c per kw-h.
[6] Included in flash candler power costs.
[7] Includes power for vacuum pump assembly and carton dispensers.
[8] Includes maintenance of scales, trays, pump assembly, and carton dispensers.
[9] Includes power and maintenance of scales, trays, pump assembly, and carton dispensers.
[10] Includes power for carton closer and packing table.
[11] Included in carton belt and drive assembly power costs.

TABLE 5.—*Productive times for performing various operations occurring in the grading, packaging, and packing of eggs*

Time item	Base time	Fatigue and personal allowances	Productive time
Egg transferring and flash-candling operations:	*Man-hours*	*Man-hours*	*Man-hours*
Obtain, open, and position 100 full cases	0. 20	0. 03	0. 23
Remove 1,400 empty filler-flats	. 54	. 05	. 59
Place 3,000 dozen eggs on flash candler-conveyor, using 30-egg spring lifter [1]	1. 37	. 21	1. 58
Transfer 1,200 filler-flats of eggs to reject shelf	1. 00	. 10	1. 10
Flash-candle eggs [2]	2. 77	. 42	3. 19
Close 100 empty cases and pass cases to carton packer	. 17	. 02	. 19
Carton and filler-flat packing operations:			
Obtain, open, and position 100 empty cases	. 25	. 03	. 28
Pack 3,000 cartons of eggs in cases	1. 28	. 19	1. 47
Pack 1,200 filler-flats of eggs in cases	1. 60	. 16	1. 76
Close 100 full cases and place cases on conveyor	. 28	. 04	. 32
Carton forming and carton storing operations:			
Open 12 boxes of cartons	. 03	—	. 03
Place 3,000 cartons in carton setup machine	. 63	. 09	. 72
Close and dispose of 12 empty carton boxes	. 02	—	. 02
Store 3,000 cartons in storage rack	. 53	. 05	. 58
Carton supplying operations:			
Place 3,000 cartons in carton dispenser magazines	. 68	. 07	. 75
Transfer 3,000 cartons from storage rack to manual packaging shelf	. 98	. 15	1. 13
Package 3,000 dozen small and peewee eggs	5. 28	. 79	6. 07

[1] Includes removal and replacement of smashed, checked, stained, misshapen, or dirty eggs.
[2] Includes removal and replacement of blind checks and obvious interior defects.

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